(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: 0 616 115 A1

(12) EUROPEAN PATENT APPLICATION

(21) Application number: 94103514.9

(51) Int. Cl.5: F01N 3/20

(22) Date of filing: 08.03.94

(30) Priority: 17.03.93 JP 56752/93

(43) Date of publication of application:
21.09.94 Bulletin 94/38

(84) Designated Contracting States:
DE GB

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(54) Exhaust gas purifying apparatus and method for internal combustion engine.

(57) An apparatus is provided for purifying an exhaust gas discharged from an internal combustion engine (8), which comprises a first exhaust gas passage including a nitrogen oxide removing catalyst (14) and a three way catalyst (15), a second exhaust gas passage including the three way catalyst, valve means (16) for selectively directing the exhaust gas to the first and second exhaust gas passages, and means (18) for controlling the valve means so as to direct the exhaust gas to the first exhaust gas passage to thereby pass the exhaust gas through the nitrogen oxide removing catalyst and the three way catalyst in the same order when the temperature of the nitrogen oxide removing catalyst is within a hydrocarbon adsorbing range of temperature thereof while the engine is warming up and to the second exhaust gas passage to thereby pass the exhaust gas through the three way catalyst when the temperature of the nitrogen oxide removing catalyst exceeds the hydrocarbon adsorbing range of temperature thereof.

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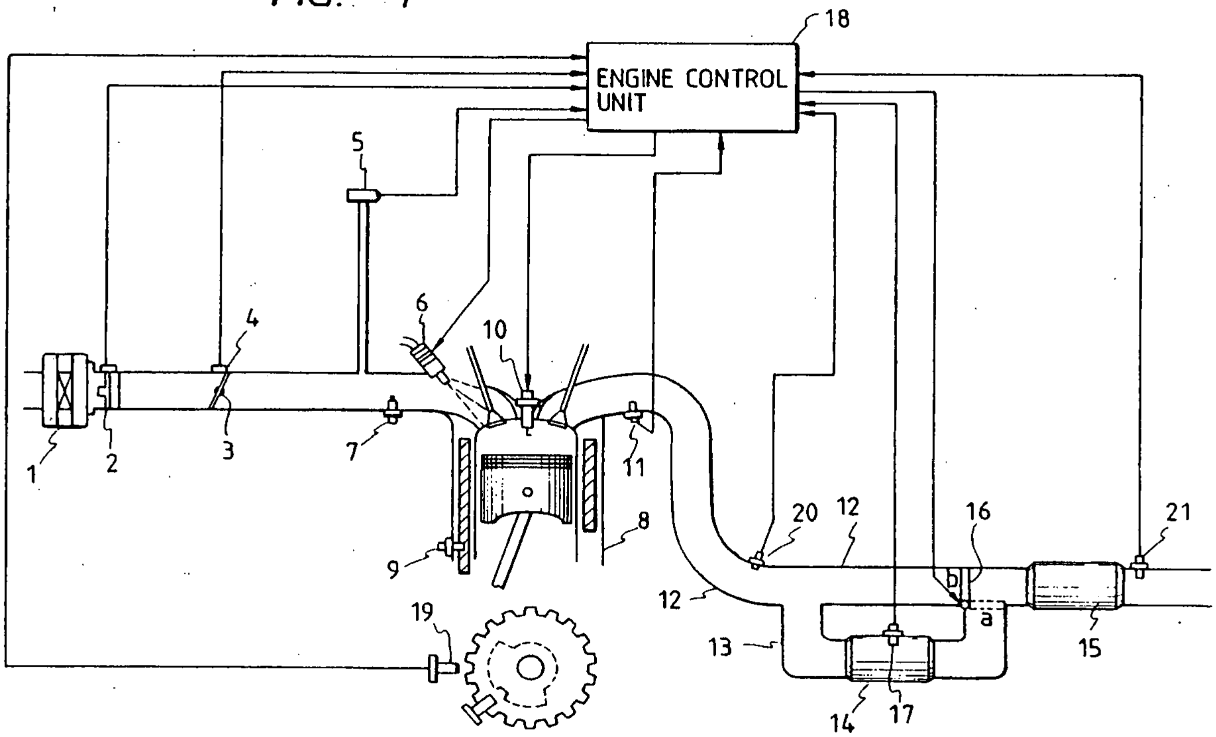
FIG. 1


ENGINE CONTROL UNIT
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The present invention relates to an exhaust gas purifying apparatus and method for an internal combustion engine, and more particularly, to an exhaust gas purifying apparatus and method suitable for purifying or removing nitrogen oxides, carbon monoxide and hydrocarbons contained in an exhaust gas discharged from an internal combustion engine which is capable of operating effectively in a lean air to fuel ratio region.

An exhaust gas discharged from an internal combustion engine for a vehicle or the like contains toxic components such as carbon monoxide (CO), hydro-carbons (HC), nitrogen oxides (NO_x) which are sources of air pollution.

Therefore, so far, technology developments on purifying the exhaust gas with catalysts have been carried out. A main exhaust gas purifying method for the internal combustion engine is a method in which a so-called three way catalyst composed of catalytic substances such as Pt, Rh, Pd and so on is used for oxidizing and purifying the HC and CO and for reducing and purifying the NO_x.

The exhaust gas purifying method using catalysts is disadvantageous in that the exhaust gas is not sufficiently purified until the temperature of the engine rises up to about 300 °C at which the catalyst exhibits its activity and therefore, the HC mostly produced when the engine starts cannot be substantially purified. Thus, it is desirable to develop a technology for purifying the HC during the period from the time when the engine starts to that when the temperature of the engine rises up to the temperature at which the catalyst exhibits its activity.

In order to solve this problem, proposed in Japanese Patent Application Laid-Open No.3-141816 (1991) is a method wherein the HC discharged when the engine starts is adsorbed by an adsorbent and the adsorbent is reactivated by its self-heating after completion of the warm-up of the engine.

Incidentally, the three way catalyst can merely purify effectively the toxic components in the case where the engine is operating substantially in the vicinity of a theoretical or stoichiometric air to fuel ratio, i. e. the concentration of co-existing O_2 in the exhaust gas is approximately 0.5 vol% or less. As well known, a narrow region in the vicinity of the stoichiometric air to fuel ratio including this is called a window. In view of this, although the air to fuel ratio for a vehicle changes according to the operating condition, the upper limit of the air-to-fuel A/F has been set at approximately 14.7 which is a stoichiometric air to fuel ratio, where A represents the total weight of air and fuel and F represents weight of fuel.

However, if the engine may be operated in an air to fuel ratio region leaner than the theoretical air to fuel ratio, i.e. lean region, fuel cost can be decreased and the amount of toxic components in the exhaust gas can also be decreased. For this reason, a "lean burn" combustion technology has been developed. In recent years, there is a strong tendency for the range of air-to-fuel ratio to widen toward a leaner region (22 ~ 24 or more measured by A/F).

Corresponding to this, a NO_x purifying or removing technology suitable for the lean burn combustion, i. e. a method to remove NO_x in the presence of oxygen, is widely studied, and a method is thought to be promising, where NO_x is reduced by using hydro-carbons as a reductant with a catalyst. For a catalyst for removing NO_x using hydrocarbons as a reductant in the presence of oxygen, i. e. a lean NO_x catalyst, zeolite carrying a transition metal such as copper is described, for example, in Japanese Patent Application Laid-Open No.1-130735 (1989), and systems utilizing the catalyst of this kind is described in Japanese Patent Application Laid-Open No.4-175416 (1992) and Japanese Patent Application Laid-Open No.3-225013 (1991).

However, in Japanese Patent Application Laid-Open No.4-175416 (1992) or Japanese Patent Application Laid-Open No.3-225013 (1991), although the method of using the lean NO_x catalyst and the three way catalyst when the air to fuel ratio is in the lean or rich region is described, the purification of the HC discharged when the engine starts is not suggested.

An object of the present invention is to provide an exhaust gas purifying apparatus and method suitable for purifying or removing nitrogen oxides, carbon monoxide and hydrocarbons contained in the exhaust gas discharged from the internal combustion engine.

Another object of the present invention is to provide an exhaust gas purifying apparatus and method for suitable for purifying or removing hydrocarbons mainly produced when the engine starts in addition to purifying or removing the exhaust gas in the full air to fuel ratio region of lean, rich and stoichiometric regions.

According to the present invention, an apparatus is provided for purifying an exhaust gas discharged from an internal combustion engine, which comprises a first exhaust gas passage including a nitrogen oxide removing catalyst and a three way catalyst,. a second exhaust gas passage including the three way catalyst, valve means for selectively directing the exhaust gas to the first and second exhaust gas passages, and means for controlling the valve means so as to direct the exhaust gas to the first exhaust gas passage to thereby pass the exhaust gas through the nitrogen oxide removing catalyst and the three way catalyst in the same

order when the temperature of the nitrogen oxide removing catalyst is within a hydrocarbon adsorbing range of temperature thereof while the engine is warming up and to the second exhaust gas passage to thereby pass the exhaust gas through the three way catalyst when the temperature of the nitrogen oxide removing catalyst exceeds the hydrocarbon adsorbing range of temperature thereof.

According to another aspect of the present invention, a method is provided of purifying an exhaust gas discharged from an internal combustion engine provided with a first exhaust gas passage including a nitrogen oxide removing catalyst and a three way catalyst and a second exhaust gas passage including the three way catalyst, which comprises the steps of judging whether or not the engine is warming up after starting, judging whether or not the temperature of the nitrogen oxide removing catalyst exceeds a hydrocarbon adsorbing range of temperature thereof, and directing the exhaust gas to first exhaust gas passage to thereby pass the exhaust gas through the nitrogen oxide removing catalyst and the three way catalyst in the same order when the temperature of the nitrogen oxide removing catalyst is within the hydrocarbon adsorbing range of temperature thereof while the engine is warming up and to the second exhaust gas passage to thereby pass the exhaust gas through the three way catalyst when the temperature of the nitrogen oxide removing catalyst exceeds the hydrocarbon adsorbing range of temperature thereof in association with the warm-up judging means and the nitrogen oxide removing temperature judging means.

The term "nitrogen oxide removing catalyst" (which is hereinafter referred simply to as "lean NO_x catalyst") is intended to mean a catalyst suitable for purifying or removing nitrogen oxides contained in the exhaust gas under a condition under which the exhaust gas includes oxygen in an amount exceeding that of oxygen necessary for substantially completely oxidizing at least carbon monoxide and hydrocarbons contained in the exhaust gas. Further, the term "three way catalyst" is intended to mean a catalyst suitable for purifying or removing nitrogen oxides, carbon monoxide and hydrocarbons contained in the exhaust gas.

It has been found through experimental studies by the inventors that the lean NO_x catalyst has a capability of adsorbing hydrocarbons contained in the exhaust gas in the range of temperature in which the lean NO_x catalyst is substantially inactive and that the lean NO_x catalyst is most effective in adsorbing hydrocarbons which are mainly produced immediately after the engine starts but cannot be removed by the three way catalyst because of inactivity of the lean NO_x catalyst. The present invention is based on such facts.

The warm-up judging means may comprise means for detecting the temperature of either one of cooling water for the engine and the exhaust gas. Since the cooling water temperature after completion of the warm-up of the engine is generally about 80 °C, an upper limit of the cooling water temperature showing that the engine is warming up may be set at, for example, 70 °C. On the other hand, in a case where the warming up degree is judged on the basis of the exhaust gas temperature, an exhaust gas temperature of, for example, 120 °C may be regarded as a standard temperature below which the engine is judged to be in a warming up condition.

According to experimental studies by the inventors, the hydrocarbon adsorbing range of temperature has been found to be approximately below 200 °C, though it depends on catalytic substances of the lean NO_x catalyst. The lean NO_x catalyst may be of substances such as zeolite, alumina, metal-silicate, silico-alumino-phosphate having various kinds of SiO_2/Al_2O_3 ratios and structures. The temperature of the lean NO_x catalyst may be directly measured by a sensor buried therein or indirectly calculated on the basis of the detecting of the exhaust gas temperature.

The lean NO_x catalyst may carry at least one member of the group consisting of first transition metals and its metal oxides such as Fe, Co, Ni, etc., noble metals and its metal oxides such as Rh, Pt, Au, etc., and lanthanoid and its metal oxides such as La, Ce, etc. by an ion exchange method or impregnation method.

According to an embodiment of the present invention, means is provided for detecting an air to fuel ratio (which is hereinafter referred simply to as "A/F") of the engine to determine in which region of a rich, lean or stoichiometric region the A/F is after completion of the warm-up of the engine. The A/F can be measured by an A/F sensor or O_2 sensor. It is preferable for the A/F range to be judged on the basis of at least one of the operating conditions such as the rotating speed of the engine, shaft torque, pulse width of the fuel injection, speed of the vehicle, pressure in the air inlet pipe and so on, when the A/F condition is determined by the engine operating conditions.

Embodiments of the present invention will now be described, by way of example, with reference to the accompanying drawings in which:

FIG.1 is a conceptual view of an exhaust gas removing apparatus showing an embodiment according to the present invention,

FIG.2 is a graph showing the temperature of a lean NO_x catalyst (or adsorbent) installed under the floor of a vehicle, the temperature of the exhaust gas at the inlet of the catalyst, the temperature of the engine cooling water, and so

forth measured in the LA-4 mode referred to in the exhaust gas regulation of the United State of America,

FIG.3 is a functional block diagram of a control system for an exhaust gas changeover valve shown in FIG.1 according to the present invention,

FIG.4 is a basic block diagram of a control system for an exhaust gas changeover valve shown in FIG.1 showing an embodiment according to the present invention,

FIG.5 is a flow chart for explaining the changeover of an exhaust gas changeover valve shown in FIG.1 according to the present invention,

FIG.6 is a conceptual perspective view, partly in section, of an embodiment of a catalyst device for use in an exhaust gas removing apparatus according to the present invention,

FIG.7 is a cross-sectional view taken along line A-A in FIG.6 when the exhaust gas changeover valve is at its closed position,

FIG.8 is a cross-sectional view taken along line A-A of FIG.6 when the exhaust gas changeover valve is at its open position, and

FIG.9 is a conceptual view of an exhaust gas removing apparatus showing another embodiment according to the present invention.

Turning to FIG.2 in advance of the reference to FIG.1, shown in FIG.2 are curves representing the temperature (d) of the lean NO_x catalyst (or absorbent) installed under the floor of a vehicle, the temperature (c) of exhaust gas at the inlet of the catalyst, the temperature (b) of the cooling water, the vehicle speed (e) and the hydrocarbon adsorbing range of temperature (a) of the catalyst. As seen from FIG.2, the temperature of the exhaust gas rises merely up to about 200°C during the period of 120 seconds after the engine starts and not reaches 300 to 350°C in which the catalyst sufficiently exhibits its catalytic function, and thus during this period a large amount of hydrocarbons are exhausted without purification. As readily seen, the hydrocarbon adsorbing range of temperature, i. e. active temperature range, of the lean NO_x catalyst is approximately below 200°C, though it depends on the carrier and carried substances of the catalyst. This means that the catalyst can exhibit its function as an adsorbent for hydrocarbons during about 120 seconds after the engine starts during which a large amount of hydro-carbon is exhausted. Further, during this period, the temperatures of both the exhaust gas and the cooling water are so low that these temperatures may be detected and used to judge the starting condition.

Referring to FIGS.1 and 3, an exhaust gas purifying apparatus as an embodiment of the present invention comprises an internal combustion engine 8 for a vehicle in which the lean burn combustion can be made; an exhaust gas removing system and its condition detecting means having a lean NO_x catalyst 14 provided in a bypath exhaust gas passage 13, a three way catalyst 15 provided in a main exhaust gas passage 12, an exhaust gas temperature sensor 20, an A/F sensor 11, a lean NO_x catalyst temperature sensor 17 and an exhaust gas changeover valve 16 provided in the cross portion of the main exhaust gas passage 12 and the bypath exhaust gas passage 13 on the outlet side thereof so as to be positioned at the downstream end of the bypath exhaust gas passage 13; an internal combustion engine operating condition detecting means having a cooling water temperature sensor 9, a throttle aperture sensor 4 for sensing the aperture or opening degree of a throttle valve 3, an inlet air temperature sensor 7, an inlet pipe pressure sensor 5 and an air flow sensor 2; an alarm sensor 21 for alarming abnormality of the temperature of the three way catalyst 15; and an engine control unit 18 capable of controlling the exhaust gas changeover valve 16. In operation, the inlet air to the engine is filtered by an air cleaner 1, the flow rate of which is measured by the air flow sensor 2. The air flow sensor 2 generates an electric signal 100 representing the measured flow rate, which is input to the engine controlling unit 18. The air flow rate is determined by the opening degree of the throttle valve 3, which is sensed by the throttle aperture sensor 4 for generating an electric signal 107 representing the opening degree of the throttle valve 3 so as to input the signal 107 to the engine controlling unit 18. The pressure sensor 5 senses the pressure in the air inlet pipe and converts this pressure into an electric signal 109, which is introduced into the engine controlling unit 18. The fuel is injected into the engine 8 by a fuel injector 6, the quantity of which is calculated by the engine controlling unit 18 on the basis of an electric signal 105 representing the temperature of the cooling water sensed by the cooling water temperature sensor 9, the electric signal 100 representing the air flow rate, an electric signal 101 representing the engine rotating speed sensed by a crank angle sensor 19, and so on. The mixed gas sucked into the engine 8 is ignited with a spark plug 10 and burned on the basis of a control signal from the engine controlling unit 18 to the spark plug 10 and the burned mixed gas is discharged through the main exhaust gas passage 12 as an exhaust gas. The A/F sensor 11 is provided at the exit of the engine to sense the A/F and convert the sensed A/F into an electric signal 104. It is also possible to use an O_2 sensor instead of the A/F sensor 11. The A/F is feedback-controlled on the basis of the electric signal 104 sensed by the A/F sensor 11 (or the O_2 sensor). The lean

temperature sensor 17 senses the temperature of the lean NO_x catalyst and converts it into an electric signal 115 so as to conduct it to the engine controlling unit 18. The engine control unit 18 is further supplied with an electric signal 116 representing the temperature of the exhaust gas sensed by the exhaust gas temperature sensor 20 and an electric signal 114 representing the vehicle speed.

The detected temperature of the exhaust gas and that of the cooling water can be used to judge whether or not the engine is warming up. The temperature of the lean NO_x catalyst may be inferred from the temperature of the exhaust gas in place of being directly sensed by the lean NO_x catalyst temperature sensor 17.

The A/F may be obtained by using control signals thereof for setting the engine operating condition instead of the output signal of the A/F sensor 11. Such control signals comprise the engine rotating speed signal 101, the aperture signal 107 of the throttle valve 3, the flow rate signal 100 of the inlet air, the pressure signal 109 in the inlet pipe, the vehicle speed signal 114 and so on.

Referring to FIG.4, the engine controlling unit 18 comprises an I/O LSI serving as an input/output interface of the engine controlling unit 18, a microprocessing unit MPU, a random access memory RAM and a read only memory ROM. The signals from the sensors or the like are led through the I/O LSI to the MPU in which the signals are processed in such a manner as comparison with data in the RAM and ROM and then are output. The output signal 203 is used to control the exhaust gas changeover valve 16.

The exhaust gas changeover valve 16 is changed over between valve positions a and b on the basis of the signals from the cooling water temperature sensor 9, the exhaust gas temperature sensor 20, lean temperature sensor 17 and the A/F sensor 11. Explaining this valve changeover operation by referring to FIG.5, in step 1001, the operating condition data are read out from the various operating condition sensing means. The A/F is sensed or detected in step 1002, the exhaust gas temperature T_E or the engine cooling water temperature T_C is detected in step 1003, and then the lean NO_X catalyst temperature is detected in step 1004. In step 1004, the exhaust gas temperature T_E is compared with a preset reference value $(T_E)_S$ or the engine cooling water temperature T_C is compared with a preset reference value $(T_C)_S$. Therein, when either $T_E < (T_E)_S$ or $T_C < (T_C)_S$, the processing goes to step 1006. In step 1006, the lean NO_x catalyst temperature T_N is compared with a preset reference value $(T_N)_S$, and when $T_N < (T_N)_S$, the processing goes to step 1007 and the exhaust gas changeover valve 16 is changed over to the position b. When the exhaust gas changeover valve 16 is at the position b, the exhaust gas is passed through the lean NO_x catalyst 14 and the three way catalyst 15 in the same order. This case is a case where the engine 8 is warming up after starting and therefore hydrocarbons produced immediately after the engine 8 started are adsorbed by the lean NO_x catalyst.

When either $T_E \geqq (T_E)_S$ or $T_C \geqq (T_C)_S$ in step 1005, or when $T_N \geqq (T_N)_S$ in step 1006, the processing goes to step 1008. This means that the warm-up of the engine 8 has been substantially completed. When the A/F > 14.7, i.e. the A/F is in a lean region, the processing goes to step 1009 and the exhaust gas changeover valve 16 is changed over to the position b. The hydrocarbons adsorbed by the lean NO_x catalyst 14 are released therefrom and purified or removed by the three way catalyst 15. In addition, the nitrogen oxides which are difficult to remove by the three way catalyst 15 are purified or removed by the lean NO_x catalyst 14.

When the A/F $\leqq$ 14.7, i. e. the A/F is a rich or stoichiometric region, the processing goes to step 1010 and the exhaust gas changeover valve 16 is changed over to the position a. In this case, the exhaust gas is passed through the three way catalyst 15 and the toxic components contained in the exhaust gas are purified or removed by the three way catalyst 15.

EXPERIMENT 1

A gasoline engine vehicle having the exhaust gas purifying apparatus described above was tested on a chassis dynamometer in the LA-4 mode referred to in the exhaust gas regulation of the United State of America to measure the total HC (hydro-carbon) and NO_x contained in the exhaust gas.

The gasoline engine of the vehicle having an engine displacement of 2000 cc was of an in-line four cylinder DOCH type and was operated in the lean region in which the A/F = 20 ~ 24 while keeping the vehicle speed higher than 20 km/hr and the opening degree of the throttle valve 3 at a low level. The lean NO_x catalyst used comprised a cordierite honeycomb (the opening area ratio of which is 76%) having a volume of 1.3 liters which was coated with catalytic powders composed of H-type mordenite carrying 5 wt% cobalt (calculated in terms of Co_3O_4). The three way catalyst used comprised a cordierite honeycomb (the opening area ratio of which is 76%) of volume 1.7 liters was coated with alumina and then Pt, Pd and Rh were carried thereby as catalytic components. The engine warming condition was determined on the basis of the engine cooling water temperature. The warm-up of the engine was regarded as completed when the temperature detected by the cooling wa-

ter temperature sensor 9 reached 40 °C, while the temperature of the lean NO_x catalyst was regarded as out of the hydrocarbon adsorbing range of temperature thereof when the temperature detected by the lean NO_x catalyst temperature sensor 17 reached 100 °C.

The amounts of HC and NO_x during the time of 505 seconds in the LA-4 mode after the engine started were 4.16g and 1.80g, respectively.

EXPERIMENT 2

The exhaust gas temperature sensor 20 was used as engine warming condition detecting means instead of the water temperature sensor 9 used in experiment 1. The experimental conditions were the same as in experiment 1 except that the warm-up of the engine was regarded as completed when the temperature detected by the exhaust gas temperature sensor 20 reached 150 °C.

The amounts of HC and NO_x during the time of 505 seconds in the LA-4 mode after the engine started were 4.32g and 1.85g, respectively.

EXPERIMENT FOR COMPARISON

This experiment was carried out without using the cooling water temperature sensor 9, the exhaust gas temperature sensor 20 and the lean NO_x catalyst temperature sensor 17. When the signal from the A/F sensor 11 showed that the A/F was in the lean region, the exhaust gas changeover valve 16 was changed over to the position b in response to a signal from the engine control unit 18 so that the exhaust gas was passed through the lean NO_x catalyst 14 and subsequently through the three way catalyst 15. When the signal from the A/F sensor 11 showed that the engine was in the rich or stoichiometric region, the exhaust gas changeover valve 16 was changed over to the position a so that the exhaust gas was passed through only the three way catalyst 15.

The amounts of HC and NO_x during the time of 505 seconds in the LA-4 mode after the engine started were 5.13g and 2.07g, respectively.

EXPERIMENT 3

Referring to FIGS.6 to FIG.8, the lean NO_x catalyst 14 is provided in the main exhaust gas passage 12, while the three way catalyst 15 is in the main exhaust gas passage 12 downstream from the lean NO_x catalyst. The bypath exhaust gas passage 13 is provided penetrating through the lean NO_x catalyst 14 and has therein the exhaust gas changeover valve 16 so as to selectively change over the same to the positions a and b to thereby open and close the bypath exhaust gas passage 13. When the exhaust gas changeover valve 16 is at the position b as shown in FIG.7, the exhaust gas is passed through the lean NO_x catalyst 14 and the three way catalyst 15 because the bypath exhaust gas passage 13 is closed. On the other hand, the exhaust gas changeover valve 16 is at the position a shown in FIG.8, the exhaust gas is passed through the bypath exhaust passage 13 and subsequently through the three way catalyst 15 without being passed through the lean NO_x catalyst 14 because the bypath exhaust gas passage 13 is opened. With this embodiment, the exhaust gas purifying system can be made extremely compact.

The performance of the exhaust gas purifying system was evaluated under the same condition as in experiment 1 and by the same method as therein except that the lean NO_x catalyst and the three way catalyst had a volume of 1.3 liters and a volume of 1.7 liters, respectively.

The amounts of HC and NO_x during the time of 505 seconds in the LA-4 mode after the engine started were 4.13g and 1.78g, respectively.

A hydrocarbon adsorbent 22 which the bypath exhaust gas passage 13 penetrates may be further provided in the main exhaust gas passage 12 after the lean NO_x catalyst 14 so as to be brought into close contact therewith.

EXPERIMENT 4

Referring to FIG.9, the structure and operation of an embodiment shown in FIG.9 were substantially the same as those shown in FIG.1 except that the hydrocarbon adsorbents 22 were provided in the bypath exhaust gas passage 13 on the upstream and the downstream sides of the lean NO_x catalyst. The performance of the exhaust gas purifying system was evaluated under the same condition as in experiment 1 and by the same method as therein.

The amounts of HC and NO_x during the time of 505 seconds in the LA-4 mode after the engine started were 4.12g and 1.80g, respectively.

Since it is obvious that many changes and modifications can be made in the above described details without departing from the nature and spirit of the present invention, it is to be understood that the present invention is not to be limited to the details described herein.

Claims

1. An apparatus for purifying an exhaust gas discharged from an internal combustion engine (8), comprising a first exhaust gas passage including a nitrogen oxide removing catalyst (14) and a three way catalyst (15), a second

exhaust gas passage including the three way catalyst (15), valve means (16) for selectively directing the exhaust gas to the first and second exhaust gas passages, and means (18) for controlling the valve means so as to direct the exhaust gas to the first exhaust gas passage to thereby pass the exhaust gas through the nitrogen oxide removing catalyst and the three way catalyst in the same order when the temperature of the nitrogen oxide removing catalyst is within a hydrocarbon adsorbing range of temperature thereof while the engine is warming up and to the second exhaust gas passage to thereby pass the exhaust gas through the three way catalyst when the temperature of the nitrogen oxide removing catalyst exceeds the hydrocarbon adsorbing range of temperature thereof.

2. An apparatus according to claim 1, further comprising means for judging whether or not the engine is warming up after starting and means for judging whether or not the temperature of the nitrogen oxide removing catalyst exceeds the hydrocarbon adsorbing range of temperature thereof.

3. An apparatus according to claim 2, wherein the warm-up judging means comprises means (9, 20) for detecting the temperature of either one of cooling water for the engine and the exhaust gas.

4. An apparatus according to claim 3, further comprising means (11) for detecting an air to fuel ratio of the engine to determine in which region of a rich, lean or stoichiometric region the air to fuel ratio is after completion of the warm-up of the engine, the valve means controlling means controlling the valve means so as to direct the exhaust gas to the second exhaust gas passage in association with the air to fuel ratio detecting means when the air to fuel ratio is in the rich and stoichiometric regions.

5. An apparatus according to claim 4, wherein the valve means controlling means controls the valve means so as to direct the exhaust gas to the first exhaust gas passage in association with the air to fuel ratio detecting means when the air to fuel ratio is in the lean region.

6. An apparatus according to claim 5, wherein the valve means controlling means controls the valve means so as to direct the exhaust gas to the second exhaust gas passage when the temperature of the nitrogen oxide removing catalyst exceeds the hydrocarbon adsorbing range of temperature thereof while the engine is warming up.

7. An apparatus according to claim 6, wherein the valve means controlling means compares the detected temperature of either one of the cooling water and the exhaust gas with a predetermined value.

8. An apparatus according to claim 7, wherein the nitrogen oxide removing catalyst temperature judging means comprises means (17, 20) for detecting the temperature of either one of the nitrogen oxide removing means and the exhaust gas at an outlet thereof.

9. An apparatus according to claim 8, wherein the valve means controlling means compares the detected temperature of either one of the nitrogen oxide removing means and the exhaust gas at the outlet thereof with a predetermined value.

10. An apparatus according to claim 9, wherein the air to fuel ratio detecting means compares the detected air to ratio with a predetermined value.

11. An apparatus according to claim 1, wherein the second exhaust gas passage constitutes part of a main exhaust gas passage (12) extended from the engine, the main exhaust gas passage has a bypath exhaust gas passage (13) provided upstream from the three way catalyst, and the nitrogen oxide removing catalyst is provided in the bypath exhaust gas passage so as to form the first exhaust gas passage together with the three way catalyst.

12. An apparatus according to claim 1, wherein the first exhaust gas passage further includes a hydrocarbon adsorbent (22) other than the nitrogen oxide removing catalyst, the hydrocarbon adsorbent being provided upstream from the three way catalyst.

13. An apparatus according to claim 12, further comprising means (11) for detecting an air to fuel ratio of the engine to determine in which region of a rich, lean or stoichiometric region the air to fuel ratio is after completion of the warm-up of the engine, the valve means controlling means controlling the valve means so as to direct the exhaust gas to the second exhaust gas passage in association with the air to fuel ratio detecting means when the air to fuel ratio is in the rich and stoichiometric re-

gions.

14. An apparatus according to claim 12, wherein the second exhaust gas passage constitutes part of a main exhaust gas passage (12) extended from the engine, the main exhaust gas passage has a bypath exhaust gas passage (13) provided upstream from the three way catalyst, and the nitrogen oxide removing catalyst and the hydrocarbon adsorbent are provided in the bypath exhaust gas passage so as to form the first exhaust gas passage together with the three way catalyst.

15. An apparatus according to claim 14, wherein the valve means controlling means is provided at a downstream end of the bypath exhaust gas passage.

16. An apparatus for purifying an exhaust gas discharged from an internal combustion engine (8), comprising a nitrogen oxide removing catalyst (14) through which the exhaust gas is passed, a three way catalyst (15) through which the passed exhaust gas is passed, a bypath exhaust gas passage (13) which is so provided as to penetrate the nitrogen oxide removing catalyst to thereby pass the exhaust gas through the bypath exhaust gas passage and the three way catalyst in the same order, and valve means (16) for opening and closing the bypath exhaust gas passage.

17. An apparatus according to claim 16, further comprising a hydrocarbon adsorbent (22) which the bypath exhaust gas passage penetrates.

18. A method of purifying an exhaust gas discharged from an internal combustion engine (8) provided with a first exhaust gas passage including a nitrogen oxide removing catalyst (14) and a three way catalyst(15), and a second exhaust gas passage including the three way catalyst, the method comprising the steps of judging whether or not the engine is warming up after starting, judging whether or not the temperature of the nitrogen oxide removing catalyst exceeds a hydrocarbon adsorbing range of temperature thereof, and directing the exhaust gas to first exhaust gas passage to thereby pass the exhaust gas through the nitrogen oxide removing catalyst and the three way catalyst in the same order when the temperature of the nitrogen oxide removing catalyst is within the hydrocarbon adsorbing range of temperature thereof while the engine is warming up and to the second exhaust gas passage to thereby pass the exhaust gas through the three way catalyst when the temperature of the nitrogen oxide removing catalyst exceeds the hydrocarbon adsorbing range of temperature thereof in association with the warm-up judging means and the nitrogen oxide removing temperature judging means.

19. A method according to claim 18, wherein the first exhaust gas passage further includes a hydrocarbon absorbent (22) other than the nitrogen oxide removing catalyst, the hydrocarbon adsorbent being provided upstream from the three way catalyst.

20. A method according to claim 18, further comprising the step of detecting an air to fuel ratio of the engine to determine in which region of a rich, lean or stoichiometric region the air to fuel ratio is after completion of the warm-up of the engine, the exhaust gas directing step directing the exhaust gas to the second exhaust gas passage in association with the air to fuel ratio detecting means when the air to fuel ratio is in the rich and stoichiometric regions.

21. A method according to claim 20, wherein the exhaust gas directing step directs the exhaust gas to the first exhaust gas passage in association with the air to fuel ratio detecting means when the air to fuel ratio is in the lean region.

FIG. 1

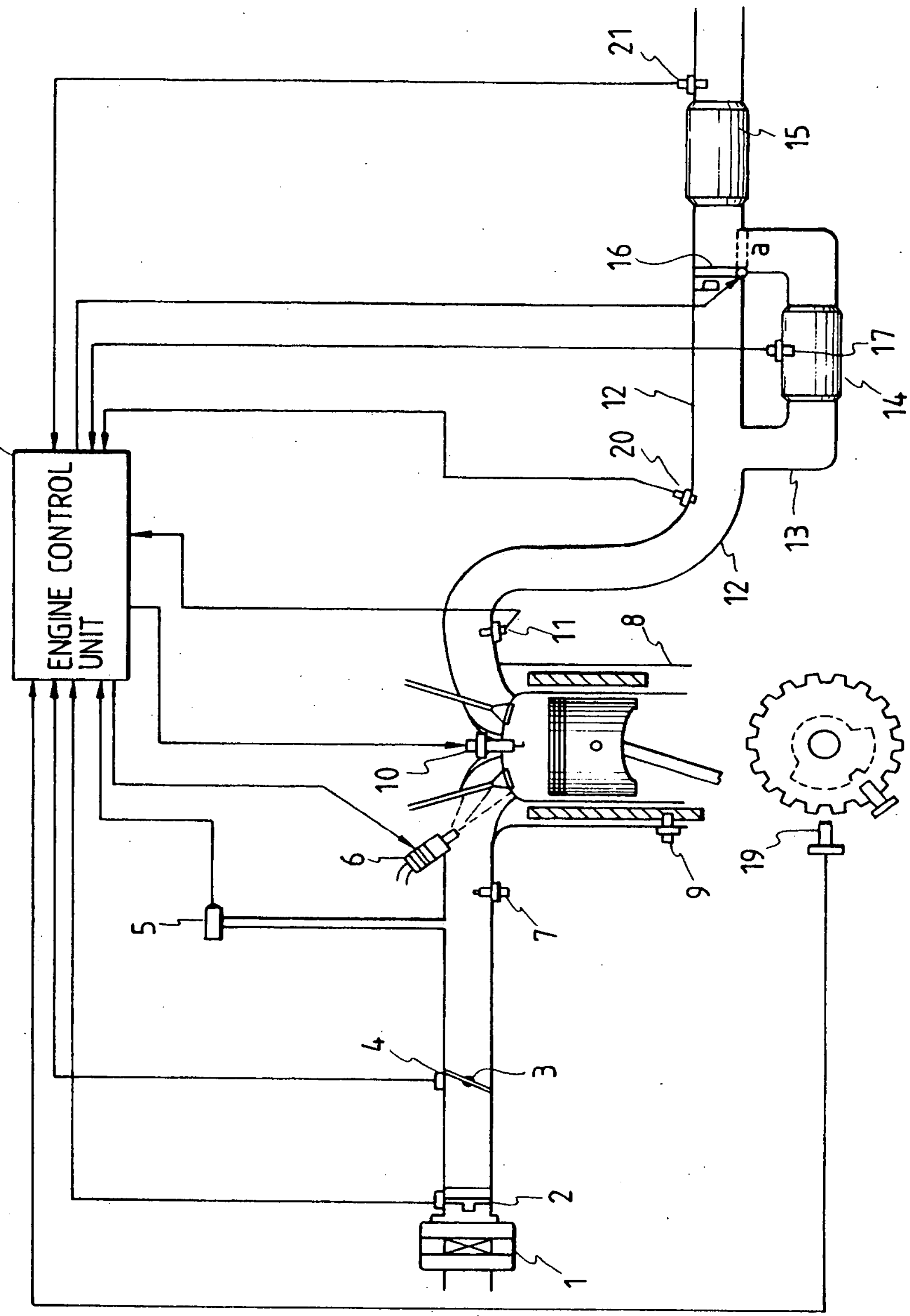

ENGINE CONTROL UNIT
18
21
15
16
a
b
17
14
12
20
13
11
8
10
6
5
7
9
19
4
3
2
1

FIG. 2

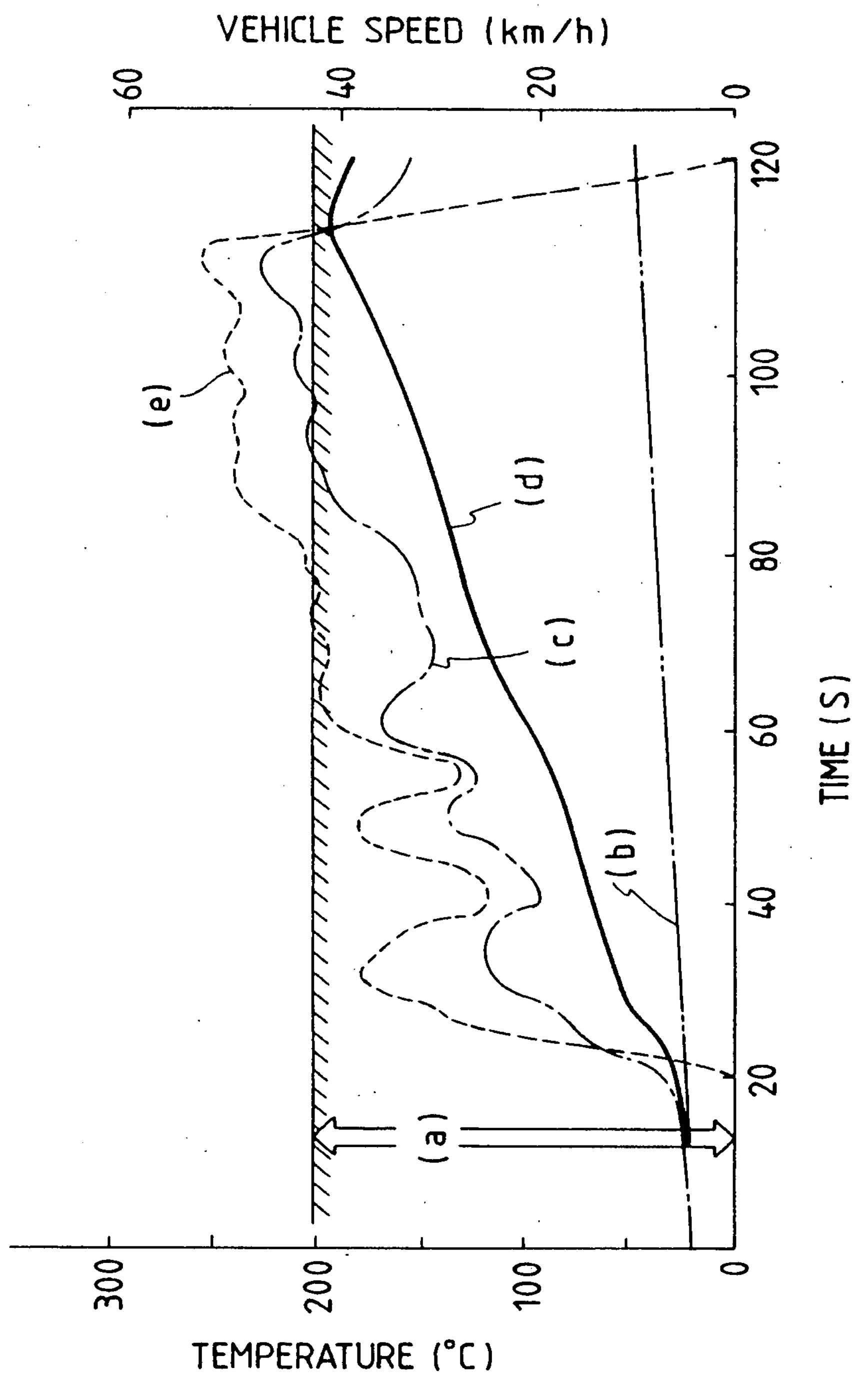

VEHICLE SPEED (km/h)
60
40
20
0
TEMPERATURE (°C)
300
200
100
0
TIME (S)
20
40
60
80
100
120
(a)
(b)
(c)
(d)
(e)

FIG. 3

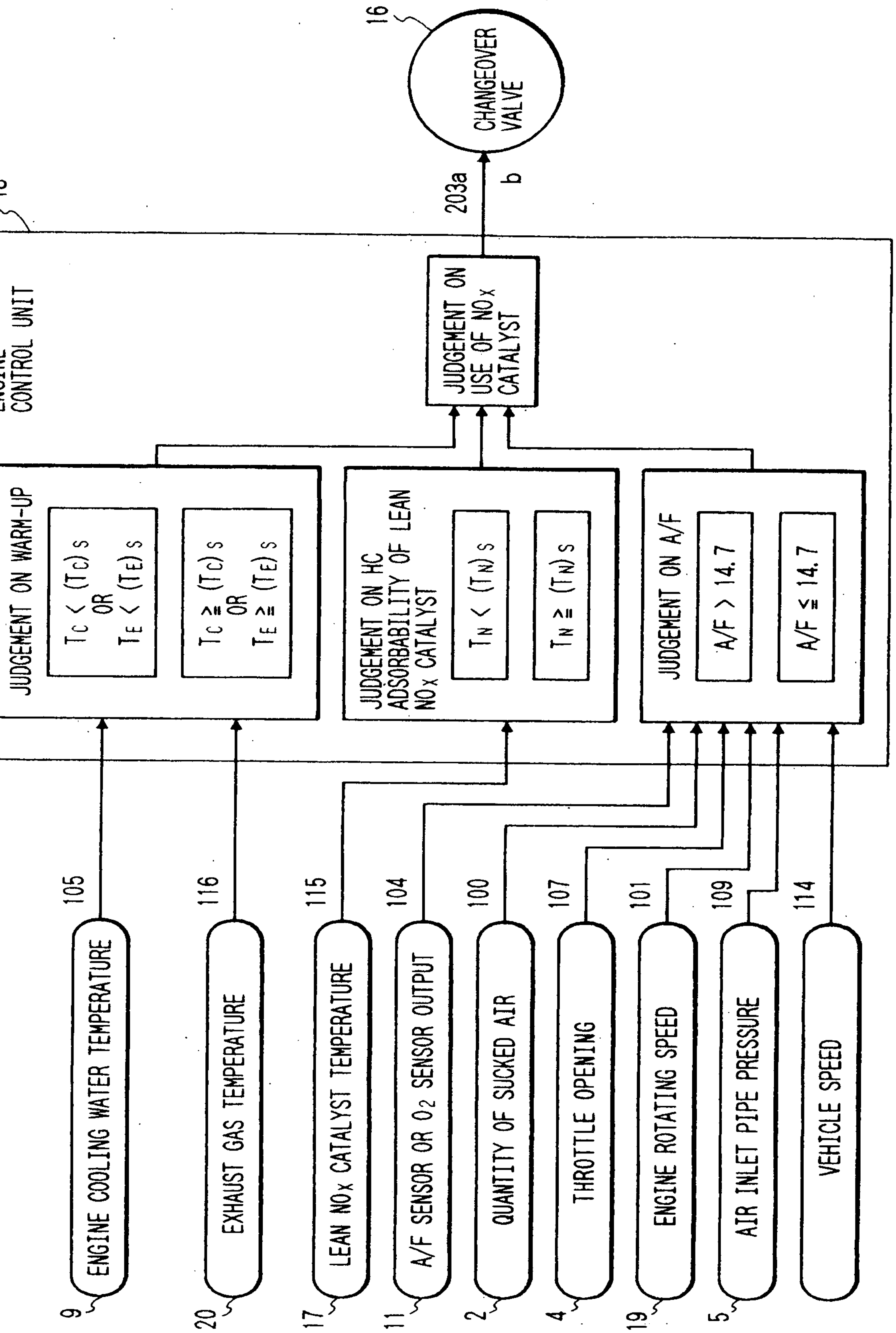

ENGINE CONTROL UNIT
18
JUDGEMENT ON WARM-UP
$T_C < (T_C)_S$ OR $T_E < (T_E)_S$
$T_C \geqq (T_C)_S$ OR $T_E \geqq (T_E)_S$
JUDGEMENT ON HC ADSORBABILITY OF LEAN NO_X CATALYST
$T_N < (T_N)_S$
$T_N \geqq (T_N)_S$
JUDGEMENT ON A/F
A/F > 14.7
A/F ≦ 14.7
JUDGEMENT ON USE OF NO_X CATALYST
203a
b
CHANGEOVER VALVE
16
9 ENGINE COOLING WATER TEMPERATURE 105
20 EXHAUST GAS TEMPERATURE 116
17 LEAN NO_X CATALYST TEMPERATURE 115
11 A/F SENSOR OR O_2 SENSOR OUTPUT 104
2 QUANTITY OF SUCKED AIR 100
4 THROTTLE OPENING 107
19 ENGINE ROTATING SPEED 101
5 AIR INLET PIPE PRESSURE 109
VEHICLE SPEED 114

FIG. 4

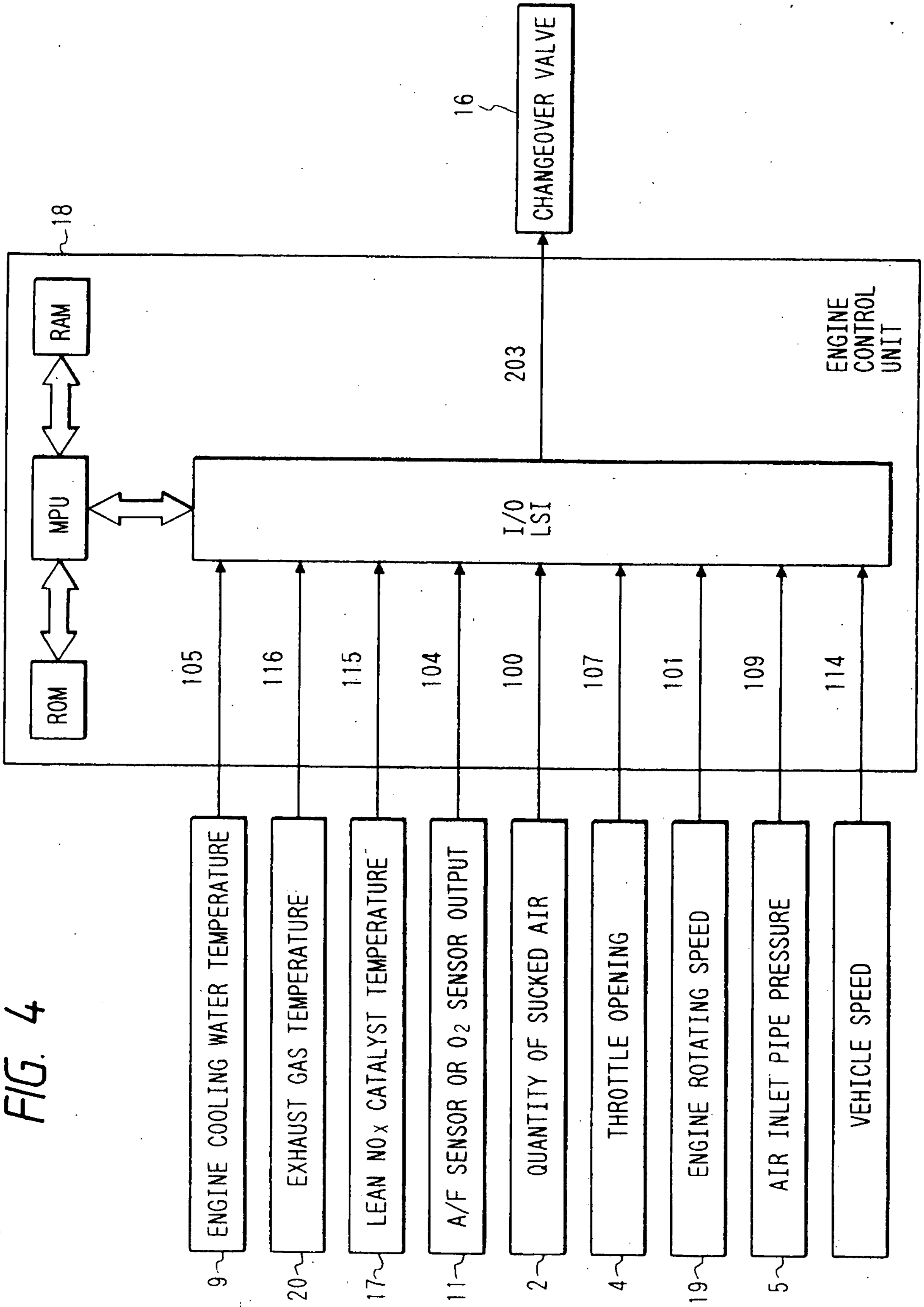

CHANGEOVER VALVE
16
18
RAM
MPU
ROM
203
I/O
LSI
ENGINE
CONTROL
UNIT
105
116
115
104
100
107
101
109
114
ENGINE COOLING WATER TEMPERATURE
EXHAUST GAS TEMPERATURE
LEAN NO_x CATALYST TEMPERATURE
A/F SENSOR OR O_2 SENSOR OUTPUT
QUANTITY OF SUCKED AIR
THROTTLE OPENING
ENGINE ROTATING SPEED
AIR INLET PIPE PRESSURE
VEHICLE SPEED
9
20
17
11
2
4
19
5

FIG. 5

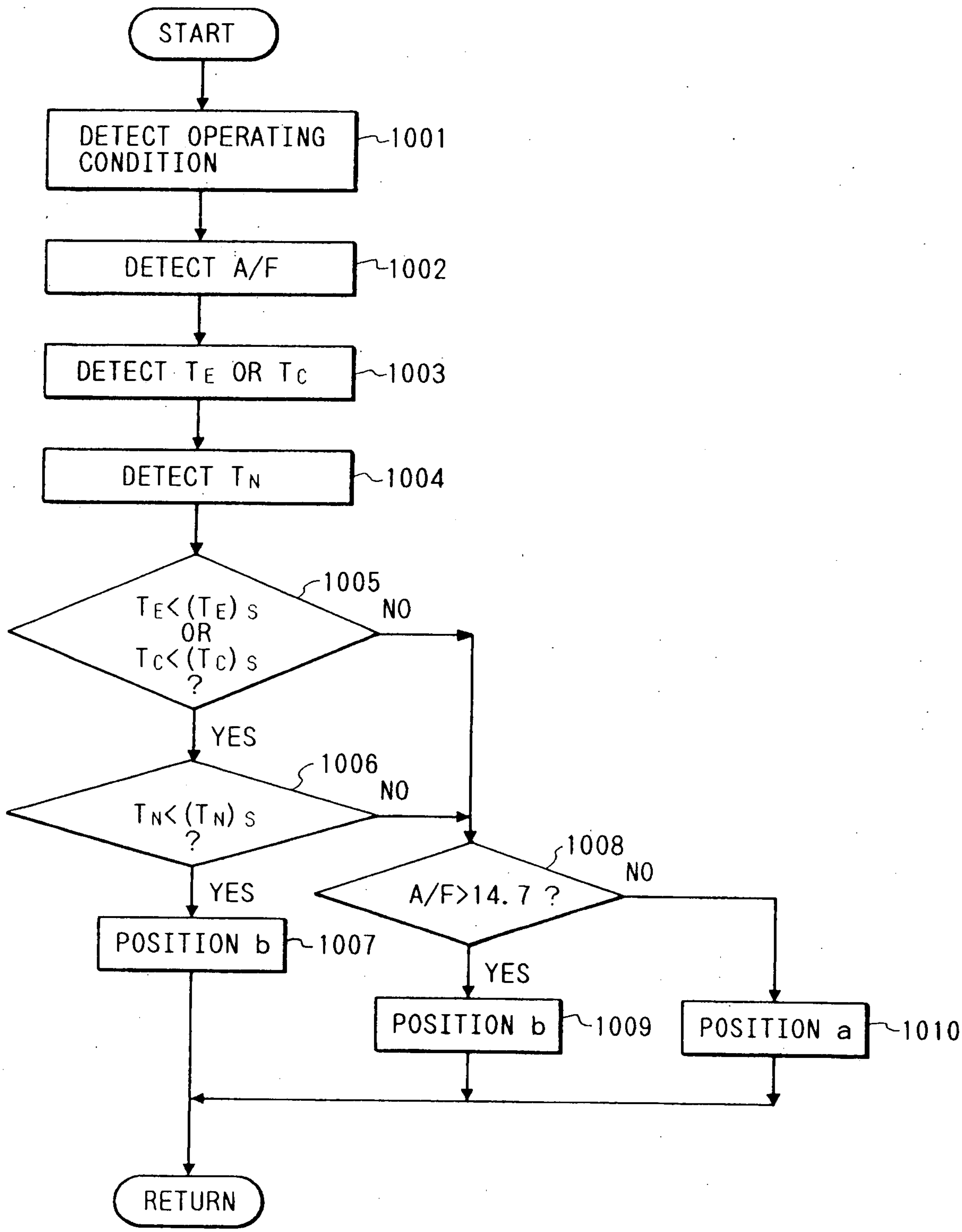

START
DETECT OPERATING CONDITION
1001
DETECT A/F
1002
DETECT T_E OR T_C
1003
DETECT T_N
1004
$T_E<(T_E)_S$ OR $T_C<(T_C)_S$?
1005
NO
YES
$T_N<(T_N)_S$?
1006
NO
YES
POSITION b
1007
A/F>14.7 ?
1008
NO
YES
POSITION b
1009
POSITION a
1010
RETURN

FIG. 6

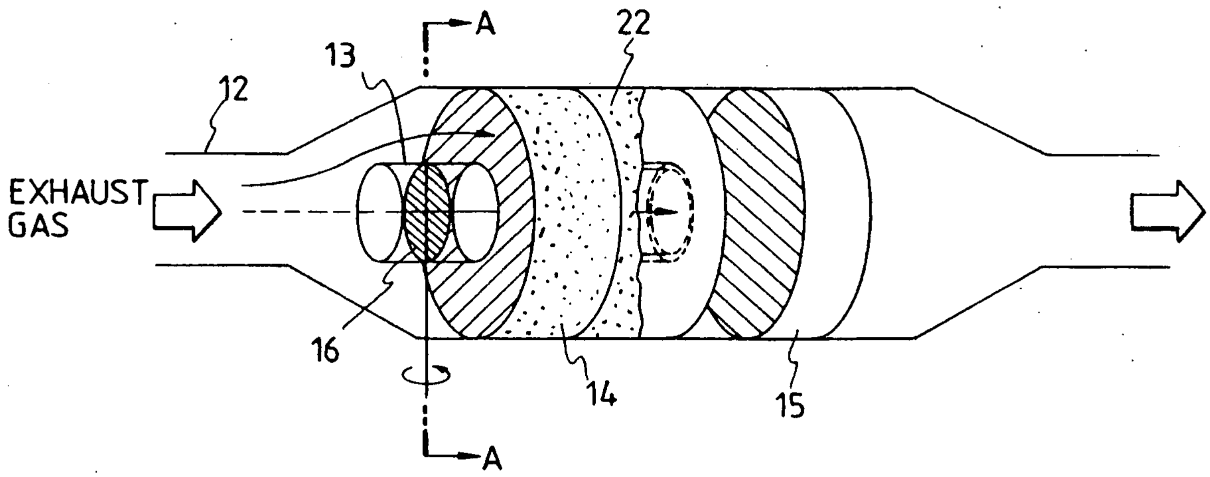


FIG. 7

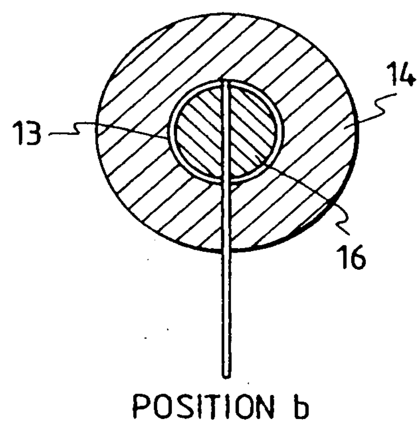


FIG. 8

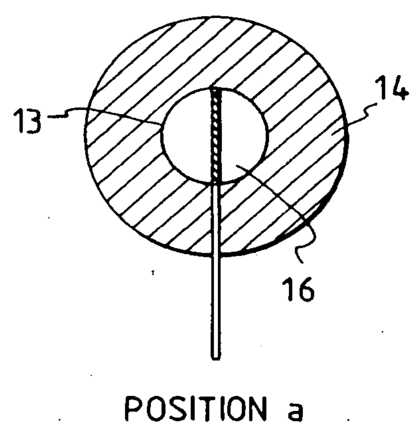
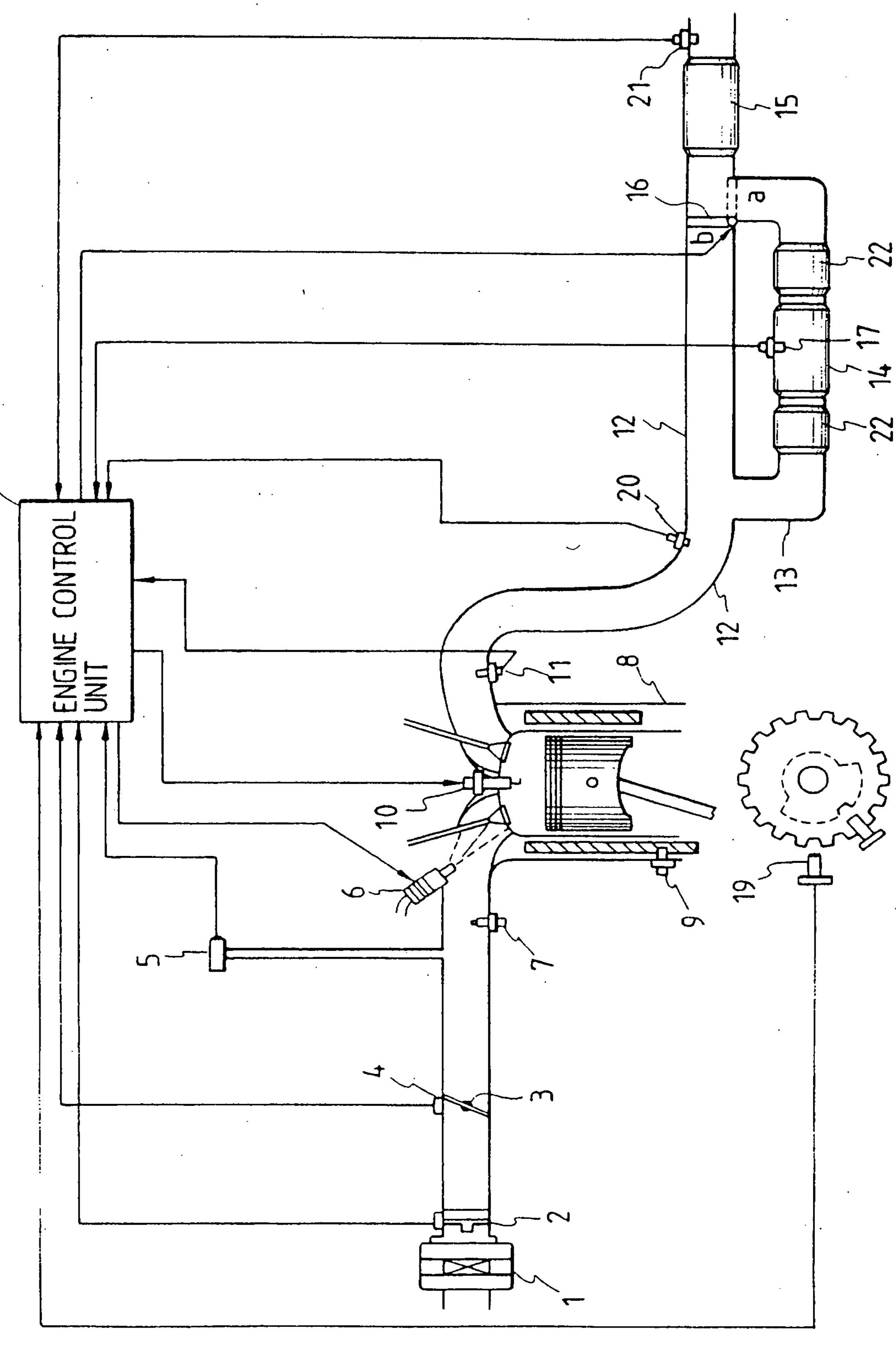


FIG. 9


ENGINE CONTROL
UNIT
18
1
2
3
4
5
6
7
8
9
10
11
12
12
12
13
14
15
16
17
19
20
21
22
22
a
b

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 94 10 3514

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.5)
X	US-A-5 051 244 (DUNNE) * column 4, line 34 - column 6, line 44 * * column 9, line 12 - line 46; figure 1 * ---	1-3,11, 16-18	F01N3/20
A,D	PATENT ABSTRACTS OF JAPAN vol. 15, no. 358 (M-1156)10 September 1991 & JP-A-03 141 816 (TOYOTA MOTOR CORP) 17 June 1991 * abstract * & EP-A-0 424 966 (TOYOTA JIDOSHA) ---	1	
A,P	FR-A-2 686 375 (ECIA) * claims 1-10; figures 1-3 * ---	1	
A	EP-A-0 460 542 (CORNING INCORPORATED) ---		
A	EP-A-0 485 179 (NGK INSULATORS) -----		

TECHNICAL FIELDS SEARCHED (Int.Cl.5)

F01N

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	11 May 1994	Friden, C

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
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P : intermediate document

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E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document